

Kansas Department of Health and Environment
Report of Radiological Environmental Monitoring of the Environs Surrounding
Wolf Creek Generating Station



July 2008-June 2009
Division of Health, Bureau of Environmental Health
Radiation and Asbestos Control and Right-to-Know Section
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Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

TABLE OF CONTENTS

INTRODUCTION	3
RESULTS SUMMARY	4
Results Summary Table	6
Results Comparison Table	7
SAMPLE RESULTS	8
Attachment 1: Inhalation Pathway	8
Air Samples	8
Table 1: Weekly Air particulate/Iodine monitoring	8
Graph 1 Weekly Air Particulate ⁷ Be Activity	9
Attachment 2: Airborne Pathway	10
Soil Samples	10
Table 2 Annual Samples for airborne radionuclide deposition on soil	10
Table 3 Random samples for airborne radionuclide deposition on soil	10
Attachment 3: Direct Radiation Pathway	11
OSLD Samples	11
Table 4: Quarterly direct radiation monitoring (mR)	11
Table 5 Co-located quarterly direct radiation monitoring (mR)	12
Graph 2 Quarterly direct radiation results for KDHE OSLD sites	13
Graph 3 Quarterly direct radiation monitoring results for co-located OSLD sites	13
Graph 4 Historical KDHE direct radiation monitoring results	14
Attachment 4: Waterborne Pathway	14
Surface Water	14
Table 6 Monthly samples for waterborne radionuclides in surface water	15
Table 7 Annual samples for deposition of airborne radionuclides in surface water	15
Graph 6 Comparison of monthly surface water tritium results (pCi/L)	15
Graph 7 Historical KDHE surface water tritium results	16
Ground Water	16
Table 8 Quarterly samples for waterborne radionuclides in ground water	17
Graph 8 Historic Owner Controlled Area Groundwater Tritium	18
Shoreline and Bottom Sediments	18
Table 9 Annual samples for waterborne radionuclides in sediments	19
Table 10 Random samples for waterborne radionuclides in sediments	20
Aquatic Vegetation and Algae	21
Table 11 Annual samples for waterborne radionuclides in aquatic vegetation	21
Table 12 Random samples for waterborne radionuclides in aquatic vegetation	21
Attachment 5: Ingestion Pathway	222
Milk Samples	22
Table 13 Quarterly samples for radionuclides in milk	22
Fish/Game Animals/Domestic Meat Samples	22
Table 14 Annual samples for radionuclides in fish (pCi/kg, wet)	23
Table 15 Random samples for radionuclides in game	23
Terrestrial Vegetation/Human Food Products	244
Table 16 Annual samples for radionuclides in terrestrial vegetation/human food products	24
Table 17 Random samples for radionuclides in terrestrial vegetation/human food products	24
Attachment 6: KDHE Radiochemistry Laboratory	25
Quality Assurance	25
Equipment	25
Table 18 Method Detection Limits	26
Attachment 7: Maps	28
Map 1 OSLD Locations	28
Map 2 Routine Sample Locations	29
Map 3 Random Sample Locations	30

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

INTRODUCTION

Wolf Creek Generating Station (WCGS) is a pressurized water nuclear reactor capable of producing over 1,200 megawatts of electrical power. Located near Burlington Kansas, the plant is operated by Wolf Creek Nuclear Operating Corporation (WCNOC). The facility releases radioactive material to the environment in the form of liquid and gaseous effluents. This report details the results of surveillance of the environs surrounding WCGS conducted by the Kansas Department of Health and Environment (KDHE) from July 1, 2008 through June 30, 2009.

KDHE's Wolf Creek Environmental Radiation Surveillance (ERS) program began in 1979 in accordance with Kansas Administrative Regulation (K.A.R.) 28-19-81 with the initial selection of surface water sampling locations. The ERS program was ready for operational use in 1984, which allowed for one year of baseline data collection prior to the commercial operation of WCGS, which commenced in September 1985. The ERS program parallels (and partially overlaps) the WCNOC Radiological Environmental Monitoring Program (REMP).

The purpose of the ERS program is to detect, identify, and measure radioactive material released to the environment from the operation of WCGS. Data indicating the release of elevated levels of radioactive material will be used to determine the need for corrective and/or protective actions to protect the health and safety of the public.

The ERS program includes the following monitoring methods:

- Measurement of ambient external radiation levels using optically stimulated luminescence dosimetry
- Monitoring of radionuclides present in ambient air through weekly collection and laboratory analysis of continuous air samples
- Monitoring of radionuclides present in water, terrestrial vegetation, aquatic vegetation, fish, sediments, and soil through scheduled and random sample collection and laboratory analysis.

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

RESULTS SUMMARY

The most significant radionuclide present in surface water samples collected in the Coffey County Lake is tritium (^3H), a beta emitter. The highest ^3H concentration measured in the Coffey County Lake during SFY 2009 was 13,921 pCi/l in July, 2008. This maximum Coffey County Lake ^3H concentration is 69% of the National Primary Drinking Regulation maximum contaminant level (MCL) of 20,000 pCi/l. *The water from the Coffey County Lake is not used as a drinking water source.* The average CCL surface water ^3H concentration for SFY 2009 was 11,524 pCi/l, or 58% of MCL. Coffey County Lake is not approved for any aquatic recreation other than fishing. All other non-CCL surface water and ground water samples collected in the environs of WCGS during SFY 2009 indicated no radionuclides present attributable to the operation of WCGS.

Aquatic vegetation samples are the best indicators for monitoring the seasonal fluctuations of fission and activation product levels in the Coffey County Lake. No aquatic vegetation sample showed any nuclides attributable to WCGS operation. Five trending samples and six random samples were analyzed.

Sediment samples have been excellent indicators for the long-term buildup of fission and activation product activity levels in the Coffey County Lake. The highest fission product activity in sediments during SFY 2009 was 152 pCi/kg-dry ^{137}Cs found at the Coffey County Lake Discharge Cove (WCBS-AQ-1).

Airborne sample analysis indicated that no radionuclides attributable to the operation of WCGS were present above the lower limits of detection during SFY 2009.

Sample analysis of terrestrial vegetation, soil, milk, grain, and vegetable samples collected in the environs of WCGS during SFY 2009 indicated no radionuclides present attributable to the operation of WCGS.

Samples of nine species of fish were taken from the Coffey County Lake during SFY 2009. Sample analysis of edible fish portions collected in the environs of WCGS during SFY 2009 indicated that no gamma emitters attributable to WCGS operation were present. The highest ^3H concentration in tissue was 6,814 pCi/kg-wet found in a largemouth bass sample taken from the CCL. Using an ICRP 30 dose conversion factor for ingestion ($h_{E,50}$) of 6.40×10^{-8} mrem per pCi ^3H ingested, a standard man consuming 21 kg/y of fish containing 6,814 pCi/kg ^3H would receive a committed effective dose

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

equivalent of 0.09 mrem. The projected dose equivalent is far below the 100 mrem/y regulatory limit for a member of the public.

Data from direct radiation monitoring sites revealed no significant changes from preoperational data. The lowest direct radiation levels are found closest to the WCGS. The direct radiation levels on the Coffey County Lake baffle dikes at the 1,200 m exclusion area boundary are the lowest of any monitored site. The limestone used to construct the baffle dikes has a lower natural background radioactivity than the original soil present before the construction of the Coffey County Lake. This effect of construction on the terrestrial component of natural background radiation was noted on radiation surveys conducted around the WCGS site before bringing the initial fuel load on the site. The water from the Coffey County Lake also acts as an effective shield from terrestrial radiation that was present before Coffey County Lake filling.

The ratio of KDHE results to WCNOG results ranged from 0.7-1.7. A summary of comparison data may be found in the Results Comparison Table.

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Results Summary Table

Type of Sample	Number of Sampling Stations	Total Samples Collected
Air (particulate and iodine)	5	516
Direct Radiation	31	244
Surface Water	5	40
Offsite Ground Water	6	24
Onsite Ground Water	3	12
Sediments	9	9
Random Sediments	16	16
Milk	2	8
Aquatic Vegetation	5	6
Random Aquatic Vegetation	6	6
Fish	2	19
Game Animals/Domestic Meat	1	1
Soil	5	5
Random Soil	10	10
Terrestrial Vegetation	9	7
Random Terrestrial Vegetation	10	10
Total	125	933

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Results Comparison Table

Description	Average	Standard deviation	Min	Max	N
OSLD direct radiation, mR per 90 day quarter	15.3	2.9	9.5	21.5	122
Airborne particulate and radioiodine cartridge gamma isotopic analysis	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any air particulate filter or radioiodine cartridge evaluated.				
Surface water tritium (³ H), pCi/l					
John Redmond Reservoir, control (N-1/MUSH)	<350	--	--	--	12
Coffey County Lake (J1A/SP)	11524.4	1539.3	9515	13921	12
Coffey County Lake (MUDS)	10350.4	1399.7	7499	12494	12
Neosho River Near Leroy	<350	--	--	--	4
Ponds surrounding WCGS	<350	--	--	--	1
Offsite ground water tritium (³ H), pCi/l (All Stations)	<350	--	--	--	24
Onsite ground water tritium (³ H), pCi/l (All Stations)	1066.5	703.1	<350	2873	12
Water sample gamma isotopic analysis	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any surface water, drinking water, or ground water sample evaluated.				
Gamma isotopic analysis of soil, pasturage, garden vegetables, and grain.	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any soil, milk, pasturage, garden vegetable and grain sample evaluated.				
Maximum activity attributable to Wolf Creek Generating Station operation, pCi/kg					
Coffey County Lake bottom sediment, dry	¹³⁷ Cs 152.0 ± 12.2 Discharge Cove Near Stringtown Cemetery				
Coffey County Lake fish, wet	³ H 6814 ± 296 Coffey County Lake				
Analysis	Average Ratio of KDHE results to WCNO results		Comments		
OSLD Direct Radiation	1.4 N=48	12 collocated sites. Wolf Creek results significantly lower upon changing from TLDs to OSLDs.			
Surface Water ³ H	1.1 N=12	Coffey County lake spillway			
Sediment gamma isotopic	0.7 N=6	Comparison of ¹³⁷ Cs results			
Fish tritium (³ H) in tissue	1.7 N=7	Comparison of ³ H results.			
OSLD Direct Radiation	1.6 N=48	12 collocated sites. Wolf Creek results significantly lower upon changing from TLDs to OSLDs.			

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

SAMPLE RESULTS

Attachment 1: Inhalation Pathway

Air Samples

Air samples were collected weekly. Five air-sampling sites, four of which are collocated with WCNOG, have continuously operating low-volume air samplers contained in a fiberglass housing mounted on utility poles approximately one meter from the ground. Air samplers are located at Sharpe, KS (A-1), east of the Coffey County Lake dam (H-1), Burlington, KS (L-1), New Strawn, KS (P-1), and Harris, KS (D-1). The collocated sites include the highest calculated annual average ground level relative concentration (X/Q) area at Sharpe, the highest calculated annual average ground level relative deposition (D/Q) area at New Strawn, and a control location at Harris. An average flow rate of 30 liters per minute is used with 47 mm diameter glass fiber particulate filters and 5 percent triethylenediamine (TEDA) impregnated carbon cartridges for radioiodine activity (the major isotope of concern is ^{131}I). TEDA binds the iodine chemically and reduces losses from desorption.

Field assay of each particulate filter was performed at the time of collection. The particulate filter was counted using a thin window GM 'pancake' detector (Ludlum Model 44-40 or equivalent) and a count rate instrument. A sample net count rate of greater than two times the net count rate of the current control (Harris D-1) air sample indicates a potential anomaly and the filter is then flagged for individual gamma isotopic analysis.

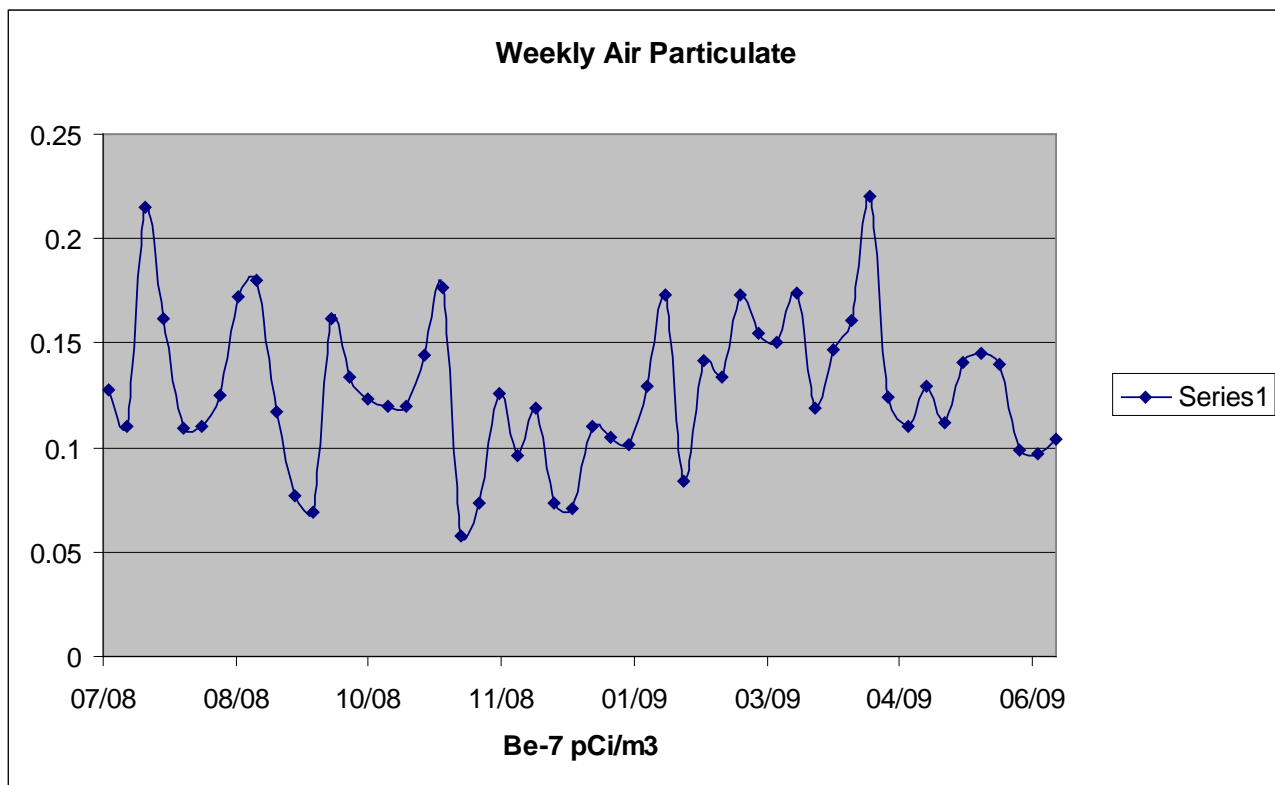
Gamma isotopic analysis was performed on two composite samples, one composed of the five particulate filters and the other of the five charcoal cartridges. Indication of ^{131}I or any other fission or activation product requires gamma isotopic analysis of each individual particulate filter and associated charcoal cartridge.

Table 1: Weekly Air particulate/iodine monitoring

Number of Samples	Average ^{7}Be Concentration	Average Iodine Concentration
52	0.13 ± 0.017	<0.03

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Graph 1 Weekly Air Particulate ^7Be Activity



Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Attachment 2: Airborne Pathway

Soil Samples

Four indicator, one control, and ten random annual soil samples were collected. Indicator soil samples were collected close to Sharpe, east of the CCL dam, at the CCL MUDS area, and at the public environmental education area. One control soil sample was collected east of WCGS at the Scott Valley Church. Random soil samples were collected at ten locations within the 50 mile zone around WCGS, nine of which were within the ten mile zone around WCGS. Soil samples collected from the Coffey County public use areas are split with WCNOG.

A gamma isotopic analysis is performed on all soil samples collected.

Table 2 Annual Samples for airborne radionuclide deposition on soil

Isotope	A-1 Sector A Sharpe	E-1 Scott Valley Church (Control)	H-1 East of CCL Dam Near HCA H-1
	2/24/2009 0.5m ²	2/10/2009 0.5m ²	11/26/08 0.5m ²
²²⁸ Ac	1232.3 ± 30	1164.2 ± 26.1	1355.8 ± 27.4
¹³⁷ Cs	274.2 ± 17.9	15.8 ± 2.7	<8.0
⁴⁰ K	13041.4 ± 838.7	12431.0 ± 791.7	12810.3 ± 824.1
	P-1 (MUDS)	R-1 (EEA)	
	1/9/2009	5/26/2009	
²²⁸ Ac	1510.7 ± 34.9	977.0 ± 23.6	
¹³⁷ Cs	406.3 ± 25.5 (405.1 ± 41.4)	23.6 ± 4.0 (27.2)	
⁴⁰ K	14051.2 ± 904.1 (11515.0 ± 753.8)	14087.2 ± 977.0 (13195.0 ± 805.9)	

Table 3 Random samples for airborne radionuclide deposition on soil

Location	Date	¹³⁷ Cs	⁴⁰ K
Oxen Lane 0.25 mi. S. of 11th Rd.	8/5/2008	222.8 ± 14.3	10845.3 ± 705.3
20th Rd. between Lynx and Kafir	8/19/2008	22.7 ± 3	15052.3 ± 938.5
End of Garner S. of 21st Rd.	9/24/2008	120.9 ± 9.8	11835.3 ± 774.1
20th Rd between Quail and Reaper	12/2/2008	95.5 ± 7.4	7172.7 ± 474.8
Near 23rd Rd and Wayside	2/10/2009	411.3 ± 2634	12128.4 ± 797.7
16th Road between US 75 and JRR	2/24/2009	<8.0	12013.7 ± 793.2
6th Rd and Kafir	1/9/2009	<8.0	10554.5 ± 706
16th and Trefoil	3/19/2009	62.9 ± 6.3	11888.7 ± 785.7
18th & Shetland	4/28/2009	37.9 ± 4.1	10566.1 ± 716
1/8th mi W of Reaper on 22nd	4/28/2009	49.8 ± 5.6	12567.2 ± 890.2

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Attachment 3: Direct Radiation Pathway

OSLD Samples

Direct radiation monitoring was accomplished using Landauer Luxel optically stimulated luminescence dosimeters (OSLDs). OSLDs are read by Landauer. OSLD readings are corrected for transit and handling exposure.

Thirty-one locations around the WCGS were monitored by KDHE, including three control locations greater than ten miles from WCGS. Two OSLDs were used per site to generate an average quarterly reading. The dosimeters are contained in specially constructed holders suspended approximately one meter above the ground. Staff members exchange OSLDs quarterly. KDHE has collocated OSLDs with WCNOG at twelve sites.

Table 4: Quarterly direct radiation monitoring (mR)

Location	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter
1. A-1 (1), North of WCGS	13.6	15.1	21.5	17.8
2. A-2, Sharpe	12.1	13.2	19.5	17.8
3. A-3, Forward Staging Area	**	**	16.0	14.3
4. B-1, East Sharpe	15.6	16.2	20.0	17.3
5. B-2, Waverly Control	14.1	15.3	20.5	16.3
6. C-1, near residence	12.1	10.5	20.0	17.3
7. D-1 (9), near residence	12.1	12.9	18.0	17.3
8. E-1, near residence	13.1	13.6	18.0	17.8
9. F-1, near residence	13.6	15.1	19.5	15.8
10. G-1 (14), WCNOG gate	13.1	14.2	19.0	17.8
11. H-0 (42), CCL baffle dike A	10.6	12.3	14.0	11.3
12. H-1, east of CCL dam	12.6	14.8	19.5	15.3
13. H-2, LeRoy control	11.1	11.9	19.0	16.8
14. J-1, near residence	11.6	12.3	18.0	15.3
15. K-1 (29), near residence	9.6	11.8	16.0	13.8
16. L-1 (27), near residence	11.6	17.3	20.0	16.3
17. L-2, Burlington	12.6	15.2	19.0	18.3
18. L-3, Coffey County Shop	10.6	11.6	18.5	16.8
19. M-1 (26), near residence	11.6	13.4	17.0	16.3
20. N-1, near pasture	13.6	14.3	19.5	18.3
21. P-0 (43), CCL baffle dike B	11.1	14.1	12.0	12.3
22. P-1, New Strawn	13.6	13.8	19.0	16.3
23. P-2, Hartford Control	11.1	11.7	16.5	15.8
24. P-3, CCL entrance	15.1	15.9	20.0	15.8
25. P-4 (46), CCL near MUDS	12.1	14.3	20.0	17.8
26. P-5, JRR public use area	13.6	15.7	21.0	15.3
27. Q-1, near residence	12.1	16.2	19.0	16.3
28. R-0 (41), Stringtown cemetery	13.1	15.8	20.5	15.8
29. R-1 (37), near residence	11.1	14.3	17.0	16.3
30. R-2 (44), CCL EEA	12.1	15.2	20.5	16.3
31. R-3, near Coffey County Airport	12.1	14.6	20.5	16.3

** Dosimeters at Forward Staging Area were inaccessible as the result of construction activities ongoing during Q1/Q2 change out period.

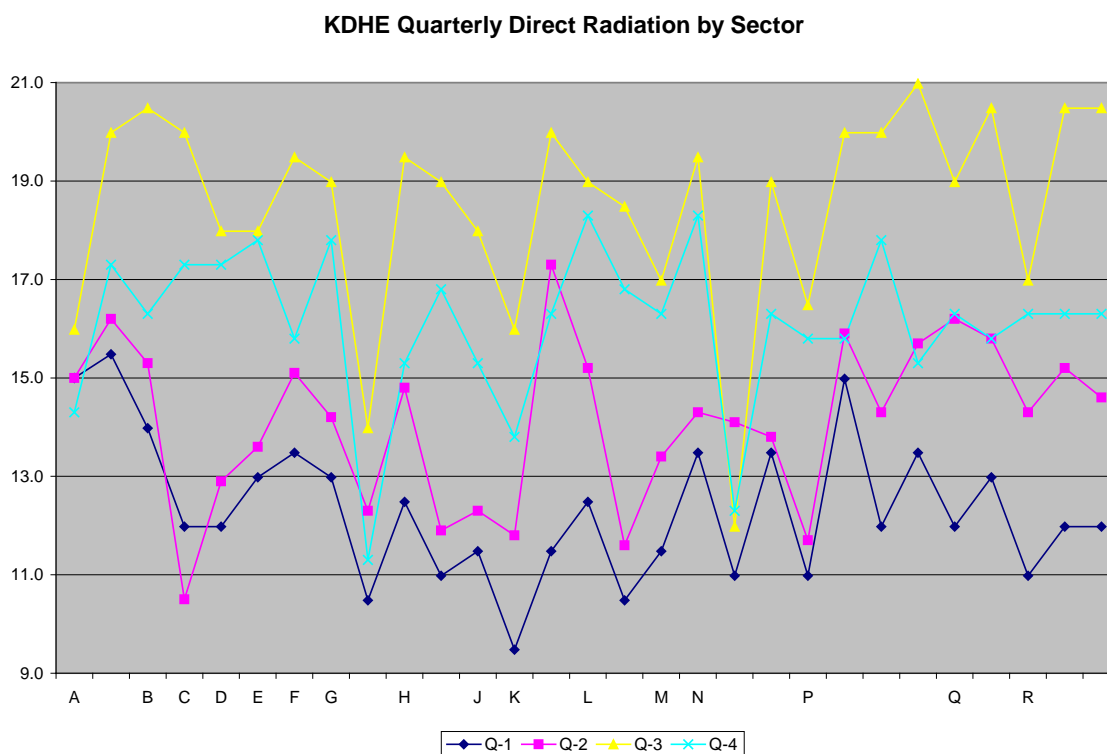
Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Table 5 Co-located quarterly direct radiation monitoring (mR)

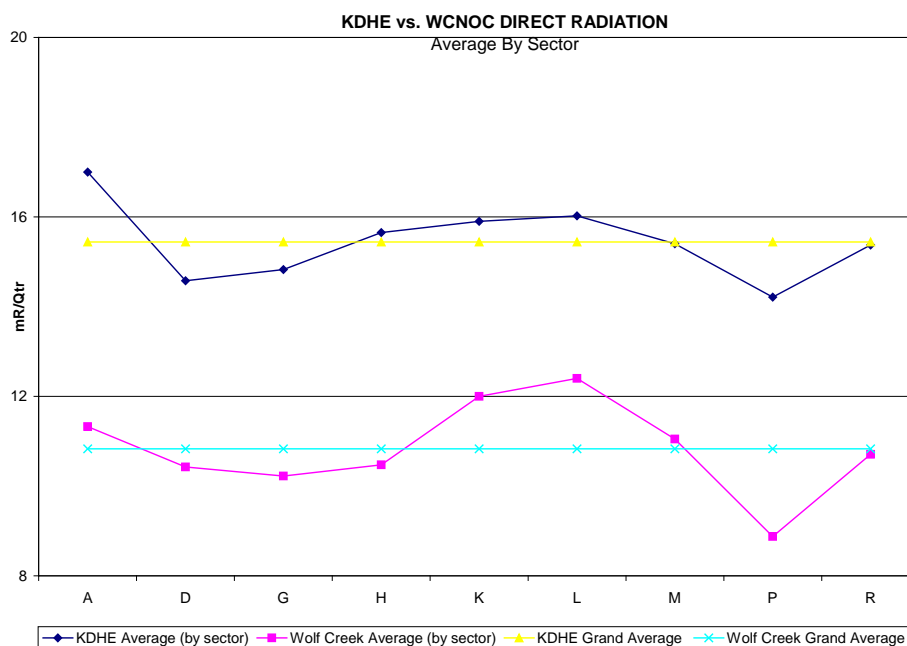
Location KDHE (WCNOC)	KDHE Monitoring period	KDHE	WCNOC
1. A-1 (1)	7/8/2008-10/9/2008	13.6	10.9
	10/9/2008-1/6/2009	15.1	11.6
	1/6/2009-4/6/2009	21.5	12.0
	4/6/2009-7/9-2009	17.8	10.8
2. D-1 (9)	7/8/2008-10/9/2008	12.1	9.6
	10/9/2008-1/6/2009	12.9	11.0
	1/6/2009-4/6/2009	18	9.7
	4/6/2009-7/9-2009	17.3	11.4
3. G-1 (14)	7/8/2008-10/9/2008	13.1	8.8
	10/9/2008-1/6/2009	14.2	12.0
	1/6/2009-4/6/2009	19	15.8
	4/6/2009-7/9-2009	17.8	13.0
4. H-0 (42)	7/8/2008-10/9/2008	10.6	3.4
	10/9/2008-1/6/2009	12.3	3.4
	1/6/2009-4/6/2009	14	6.5
	4/6/2009-7/9-2009	11.3	6.0
5. K-1 (29)	7/8/2008-10/9/2008	9.6	5.2
	10/9/2008-1/6/2009	11.8	14.3
	1/6/2009-4/6/2009	16	7.4
	4/6/2009-7/9-2009	13.8	9.8
6. L-1 (27)	7/8/2008-10/9/2008	11.6	8.4
	10/9/2008-1/6/2009	17.4	12.1
	1/6/2009-4/6/2009	20	13.5
	4/6/2009-7/9-2009	16.3	14.6
7. M-1 (26)	7/8/2008-10/9/2008	11.6	8.5
	10/9/2008-1/6/2009	13.4	11.0
	1/6/2009-4/6/2009	17	12.1
	4/6/2009-7/9-2009	16.3	9.8
8. P-0 (43)	7/8/2008-10/9/2008	11.1	3.4
	10/9/2008-1/6/2009	14.1	5.6
	1/6/2009-4/6/2009	12	8.4
	4/6/2009-7/9-2009	12.3	5.4
9. P-4 (46)	7/8/2008-10/9/2008	12.1	10.8
	10/9/2008-1/6/2009	14.3	11.0
	1/6/2009-4/6/2009	20	13.9
	4/6/2009-7/9-2009	17.8	12.5
10. R-0 (41)	7/8/2008-10/9/2008	13.1	5.8
	10/9/2008-1/6/2009	15.7	12.1
	1/6/2009-4/6/2009	20.5	8.7
	4/6/2009-7/9-2009	15.8	14.1
11. R-1 (37)	7/8/2008-10/9/2008	11.1	8.0
	10/9/2008-1/6/2009	14.3	8.8
	1/6/2009-4/6/2009	17	11.5
	4/6/2009-7/9-2009	16.3	12.5
12. R-2 (44)	7/8/2008-10/9/2008	12.1	11.2
	10/9/2008-1/6/2009	15.2	8.8
	1/6/2009-4/6/2009	20.5	13.4
	4/6/2009-7/9-2009	16.3	13.6

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Graph 2 Quarterly direct radiation results for KDHE OSLD sites

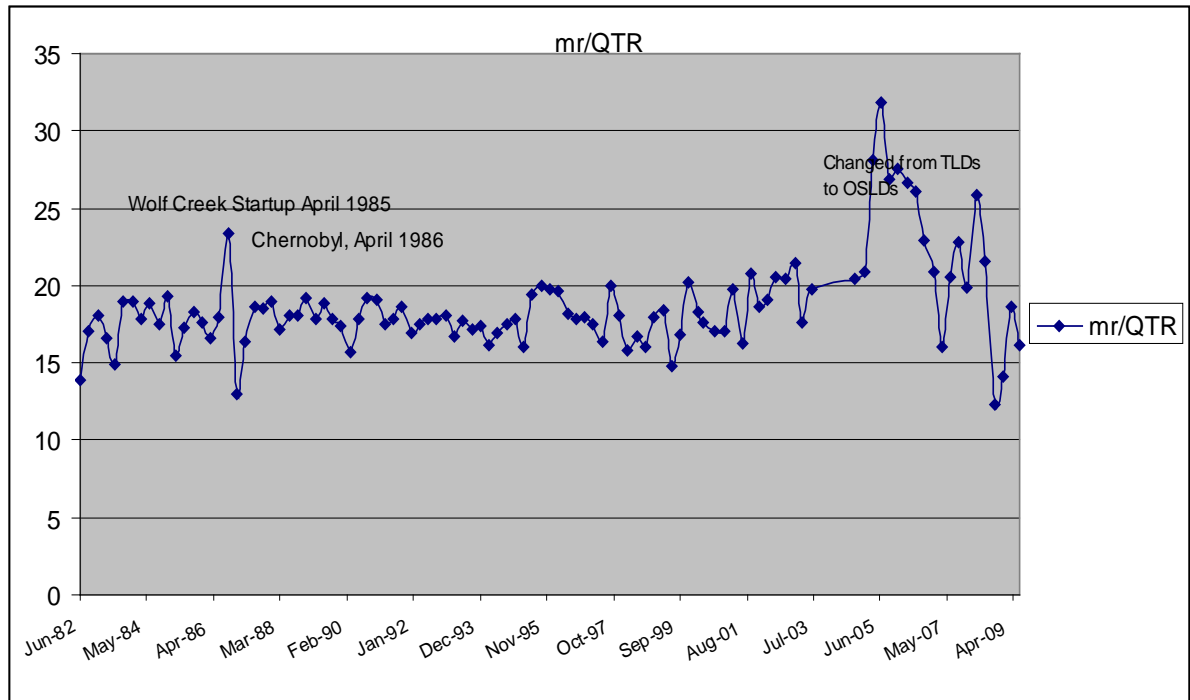


Graph 3 Quarterly direct radiation monitoring results for co-located OSLD sites



Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Graph 4 Historical KDHE direct radiation monitoring results



Attachment 4: Waterborne Pathway

Surface Water

Surface water sampling was accomplished through the collection of one-gallon grab samples at the indicated locations. A control sample was collected monthly from John Redmond Reservoir. One sample was collected monthly from the Coffey County Lake (CCL) at the spillway. One sample was collected monthly at the public fishing area on CCL, near the Makeup Discharge Structure (MUDS). Samples were collected monthly from the Neosho River near Leroy only when Coffey County Lake was overflowing to Wolf Creek at the spillway. No discharges to the river occurred during this reporting period. A sample was also collected annually from the New Strawn City Lake.

A gamma isotopic and tritium (^3H) analysis was done on each CCL water sample and ^3H analysis was done quarterly on a composite sample from JRR. Samples from John Redmond Reservoir and the Coffey County Lake Spillway were split with WCNO.

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

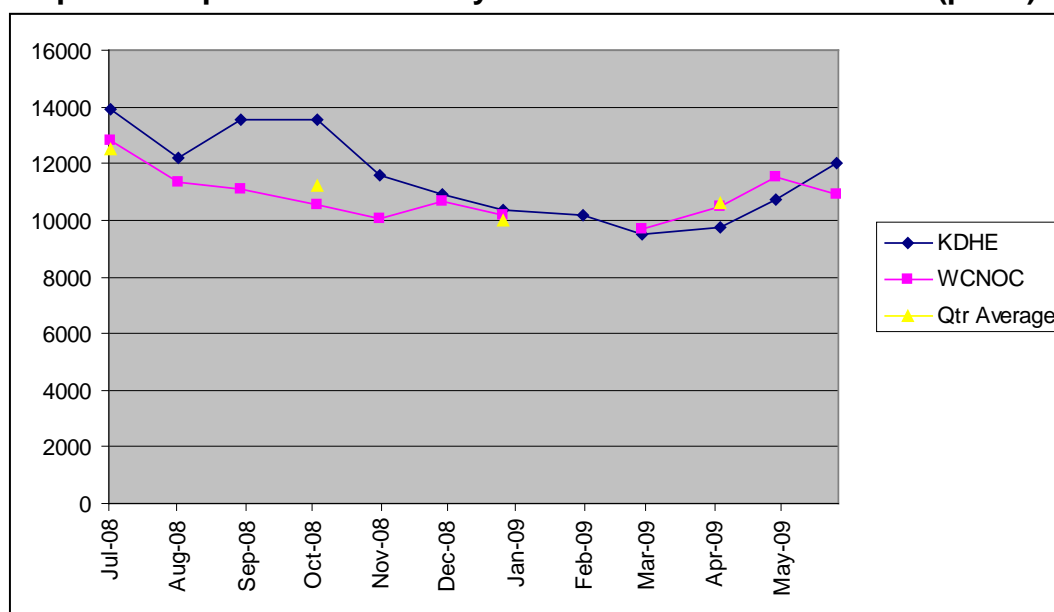
Table 6 Monthly samples for waterborne radionuclides in surface water

Date	J-1A (Spillway)		N-1 (JRR/MUSH) Control		P-1 Muds	H-1 Neosho R.	
	KDHE	WCNOC	KDHE	WCNOC	Date	KDHE	Date
7/14/2008	13921 ± 365	12782 ± 319	<350	<143	7/11/2008	12494 ± 352	
8/14/2008	12212 ± 340	11322 ± 298	<350	<147	8/26/2008	12160 ± 339	
9/11/2008	13548 ± 364	11069 ± 316	<350	<155	9/12/2008	11003 ± 324	N/A
10/16/2008	10706 ± 318	10518 ± 295	<350	<150	10/8/2008	11071 ± 324	
11/13/2008	10129 ± 315	10079 ± 292	<350	<144	11/20/2008	11063 ± 328	
12/11/2008	10923 ± 321	10694 ± 303	<350	<144	12/2/2008	10877 ± 323	
1/8/2009	10342 ± 315	9382 ± 273	<350	<133	1/9/2009	8781 ± 295	
2/13/2009	10181 ± 313	10180 ± 286	<350	<145	2/10/2009	7499 ± 289	
3/12/2009	9515 ± 307	9676 ± 295	<350	<149	3/10/2009	9424 ± 305	3/17/2009
4/16/2009	9744 ± 311	10507 ± 313	<350	<153	4/21/2009	9983 ± 314	<350
5/11/2009	10745 ± 351	11530 ± 327	<350	<155	5/11/2009	9900 ± 313	5/26/2009
6/8/2009	12017 ± 185	10928 ± 293	<350	<142	6/9/2009	9995 ± 315	<350

Table 7 Annual samples for deposition of airborne radionuclides in surface water

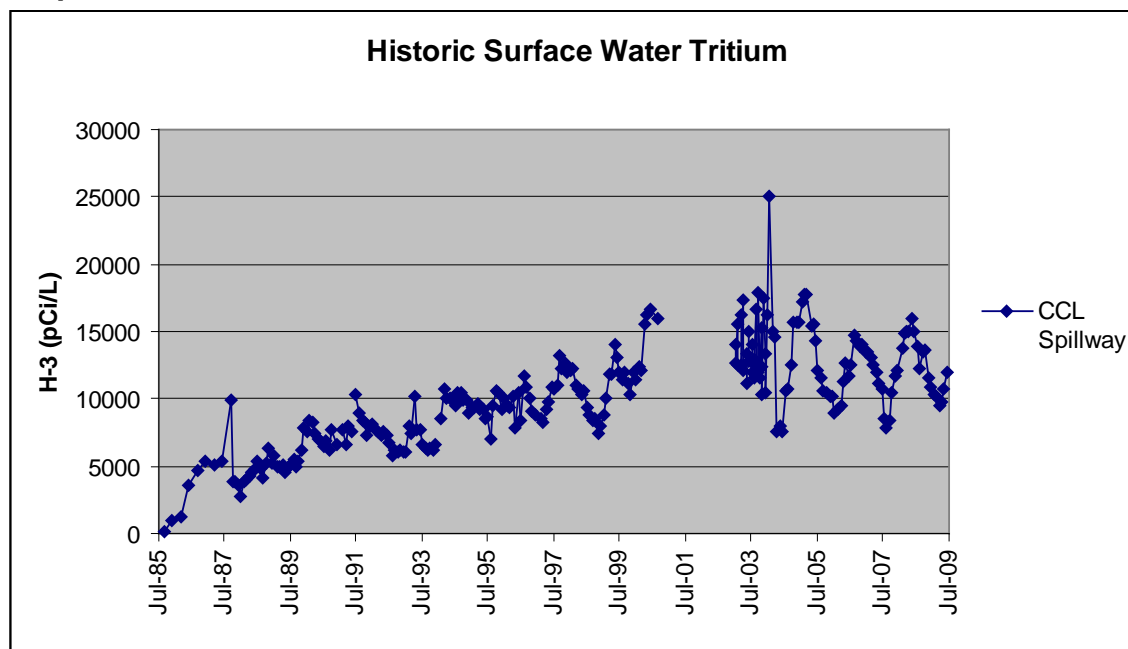
Location	Date	Tritium (³ H)
P-1, New Strawn City Lake	4/22/2009	<350

Graph 6 Comparison of monthly surface water tritium results (pCi/L)



Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Graph 7 Historical KDHE surface water tritium results



Ground Water

Ground water was collected quarterly offsite at wells in sectors B (control), C, F, G, and J. The control sample location was hydrologically up gradient from the facility and the other four are hydrologically down gradient. Samples were split with WCNOG. Samples were collected within the Wolf Creek owner controlled area along the Essential Service Water-buried pipe (two locations) and in the Wolf Creek protected area near the Auxiliary Building.

Gross alpha, beta, tritium and gamma isotopic analysis are done on each sample.

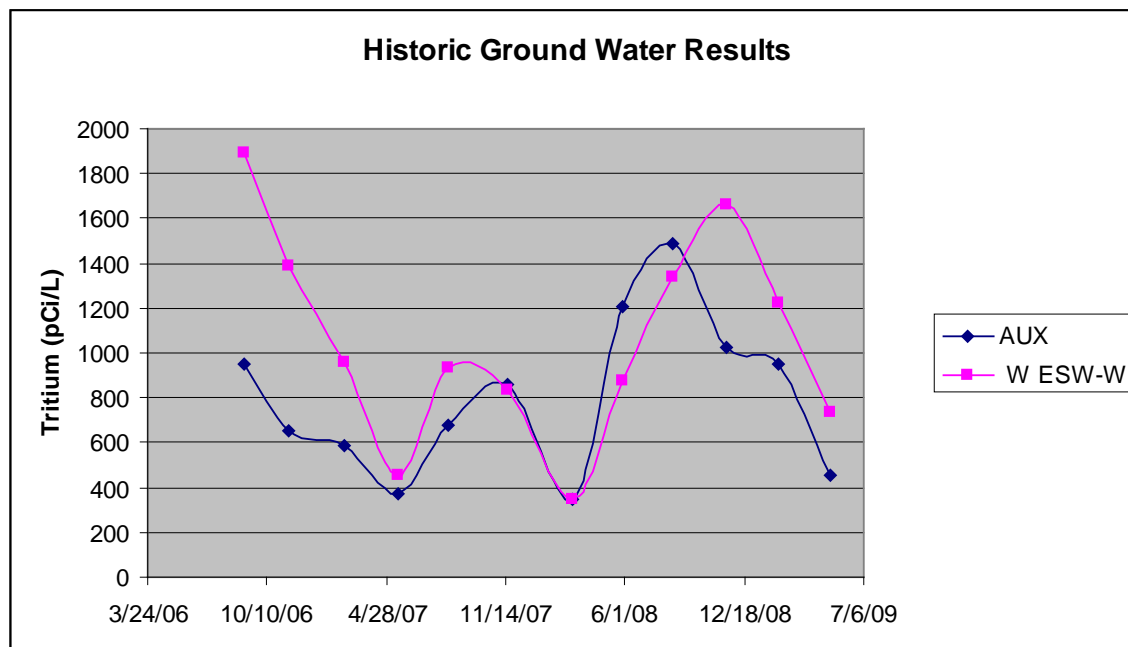
Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Table 8 Quarterly samples for waterborne radionuclides in ground water

B-1 (B-12)			G-1 (G-2)		
Date	H-3 KDHE	WCNOC	Date	H-3 KDHE	H-3 WCNOC
8/22/2008	<350	<151	8/22/2008	<350	<151
11/25/2008	<350	<148	11/25/2008	<350	<148
2/18/2009	<350	<146	2/18/2009	<350	<146
5/15/2009	<350	<163	5/15/2009	<350	<163
F-1 (F-1)			C-2 (C-49)		
Date	H-3 KDHE	WCNOC	Date	H-3 KDHE	H-3 WCNOC
8/22/2008	<350	<151	8/22/2008	<350	<151
11/25/2008	<350	<148	11/25/2008	<350	<148
2/18/2009	<350	<146	2/18/2009	<350	<146
5/15/2009	<350	<163	5/15/2009	<350	<163
J-1 (J-2)			C-1 (C10)		
Date	H-3 KDHE	WCNOC	Date	H-3 KDHE	H-3 WCNOC
8/22/2008	<350	<151	8/22/2008	<350	<151
11/25/2008	<350	<148	11/25/2008	<350	<148
2/18/2009	<350	<146	2/18/2009	<350	<146
5/15/2009	<350	<163	5/15/2009	<350	<163
Auxiliary Building			WEST ESW-W		
Date	H-3 KDHE	H-3 WCNOC	Date	H-3 KDHE	H-3 WCNOC
8/21/2008	1485 ± 193	1483 ± 141	8/21/2008	1337 ± 201	1171 ± 132
11/19/2008	1024 ± 179	998 ± 113	11/19/2008	1663 ± 192	1504 ± 129
2/13/2009	948 ± 179	905 ± 112	2/13/2009	1227 ± 184	1284 ± 124
5/12/2009	454 ± 170	496 ± 98	5/12/2009	737 ± 179	888 ± 115
EAST ESW-W					
Date	H-3 KDHE	H-3 WCNOC			
11/19/2008	<350	<145			
2/13/2009	<350	<144			
5/12/2009	<350	<156			
ESW-W-NE					
Date	H-3 KDHE	H-3 WCNOC			
8/21/2008	2873 ± 217	2843 ± 176			

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Graph 8 Historic Owner Controlled Area Groundwater Tritium



Shoreline and Bottom Sediments

Shoreline sediment and bottom sediment were collected in the environment surrounding WCGS. Indicator bottom sediment samples were collected in the Coffey County Lake discharge cove, public environmental education area, and the CCL MUDS public access fishing area. A control sample of bottom sediment was obtained from John Redmond Reservoir. Indicator shoreline sediment was collected at the CCL discharge cove, the CCL MUDS public access fishing area, Wolf Creek below the CCL dam, and Stringtown Cemetery. A control sample of shoreline sediment was collected at JRR. Six random bottom sediments were collected on CCL. Twelve random shoreline sediments were collected on CCL and the Neosho River. The CCL and JRR samples are split with WCNOG.

A gamma isotopic analysis is done on all sediment samples collected.

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Table 9 Annual samples for waterborne radionuclides in sediments

Location	Type	Date	¹³⁷ Cs KDHE (WCNOC)	⁶⁰ Co KDHE (WCNOC)	⁴⁰ K KDHE (WCNOC)
J-1 Wolf Creek	Shoreline	7/29/2008	18.8 ± 4.3	<11.0	9532.8 ± 641.2
Q-1 CCL Discharge Cove	Shoreline	9/19/2008	26.0 ± 6.9 (160.9 ± 57.2)	<11.0 (60.9 ± 31.1)	13402.9 ± 677.2 (13846.0 ± 1172.0)
Q-1 CCL Discharge Cove	Bottom	9/19/2008	<8.0 (<25.1)	<11.0 (<14.7)	12654 ± 623.5 (11114.0 ± 620.3)
N-1 John Redmond Reservoir (Control)	Shoreline	10/17/2008	129.1 ± 9.5 (<26.7)	<11.0 (<19.8)	12948.7 ± 835.6 (9670.9 ± 679.8)
N-1 John Redmond Reservoir (Control)	Bottom	11/14/2008	61.1 ± 7.7 (<26.6)	<11.0 (<17.5)	17017.5 ± 863.6 (13202.0 ± 715.8)
R-1 Wolf Creek Environmental Education Area	Bottom	5/28/2009	46.5 ± 11.4 (51.3 ± 23.6)	<11.0 (<17.6)	10691.7 ± 749.3 (11247.0 ± 702.9)
R-1 Wolf Creek Environmental Education Area	Bottom	5/28/2009	39.6 ± 10.4 (76.5 ± 31.4)	<11.0 (<6.8)	9846.1 ± 657.7 (11096.0 ± 807.3)
P-1 CCL Public Access Fishing Area (MUDS)	Bottom	5/29/2009	112.3 ± 8.9 (<38.3)	<11.0 (<23.1)	12567.2 ± 828.6 (9825.8 ± 864.9)
R-2 Stringtown Cemetery	Shoreline	6/9/2009	152.0 ± 12.2	<11.0	11323.5 ± 805.4
Q-1 CCL Discharge Cove	Bottom	5/29/2009	(169.4 ± 82.3)	(<36.2)	(13568.0 ± 1362.0)

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Table 10 Random samples for waterborne radionuclides in sediments

Location		Date	¹³⁷ Cs	Isotope ⁶⁰ Co
CCL North End	Bottom	9/9/2008	107.8 ± 8.3	<11.0
CCL North End	Bottom	9/9/2008	39.1 ± 5.5	<11.0
CCL North End	Bottom	9/9/2008	<8.0	<11.0
CCL	Bottom	9/26/2008	132.6 ± 9.8	<11.0
CCL	Bottom	9/26/2008	<8.0	<11.0
CCL	Bottom	9/26/2008	13.3 ± 2.6	<11.0
CCL	Bottom	9/26/2008	45.6 ± 4.2	<11.0
CCL	Bottom	9/30/2008	36.7 ± 4.3	<11.0
Neosho River near Coffey County Fairgrounds	Shoreline	1/9/2009	<8.0	<11.0
Neosho River near Leroy	Shoreline	3/19/2009	<8.0	<11.0
Neosho River	Shoreline	5/29/2009	<8.0	<11.0
CCL	Bottom	6/11/09	14.8 ± 3.7	<11.0
CCL	Bottom	6/11/09	16.0 ± 2.4	<11.0
CCL	Bottom	6/11/09	<8.0	<11.0
CCL	Bottom	6/11/09	12.6 ± 2.0	<11.0
Neosho River	Shoreline	6/23/2009	<8.0	<11.0

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Aquatic Vegetation and Algae

Annual aquatic vegetation (algae and/or rooted aquatics) indicator samples were collected from the Coffey County Lake and Wolf Creek below the Coffey County Lake dam. Control samples of aquatic vegetation were obtained at John Redmond Reservoir. The Coffey County Lake samples are split with WCNOG.

Gamma isotopic analysis is performed on all aquatic vegetation samples.

Table 11 Annual samples for waterborne radionuclides in aquatic vegetation KDHE (WCNOG)

Sample ID	Location	Sample type	Date	K-40 pCi/kg	Be7 pCi/kg
WCRAJ-1-178-3.8	Wolf Creek	Water Willow	7/21/2008	28233 ± 2319	3009 ± 327
WCAL-N-1-275-3.8	JRR above dam	Spikerush	6/23/2009	20267 ± 1458	5970 ± 444
WCP-1-289-1.6	CCL MUDS	Pondweed/naiad	6/23/2009	10988 ± 1601	1510 ± 178
WCQ-1-316-0.3	CCL DC	Cattails	6/9/2009	12634 ± 1777	1121 ± 178
WCR-1-332-3.0	CCL EEA	Water Primrose	5/26/2009	10311 ± 1811 (1419.3 ± 232.2)	5732 ± 727 (972.2 ± 152.3)

Table 12 Random samples for waterborne radionuclides in aquatic vegetation

Location	Sample type	Date	K-40 pCi/kg	Be7 pCi/kg
0.25 mi. east of Shetland Rd. on 12th Rd.	Arrowhead	7/10/2008	21671 ± 1605	749 ± 110
Mathias Lake	Duckweed	7/11/2008	26154 ± 2870	4811 ± 359
N. end of CCL near 17th Rd. bridge	American Lotus	7/11/2008	19825 ± 2021	<360
8th Rd. .25 Mi. E of Planter Rd.	River Bullrush	8/5/2008	19426 ± 2059	1649 ± 272
North End Coffey County Lake	Pondweed	9/10/2008	31231 ± 2842	1573 ± 237
CCL near WC Boat Ramp	Naiad	9/10/2008	10010 ± 1062	1111 ± 161

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Attachment 5: Ingestion Pathway

Milk Samples

Milk samples were collected quarterly in Coffey County at two locations. Indicator samples were obtained from the Sunrise Dairy near Westphalia, KS. Control samples were obtained from Linsey Dairy near Lebo, KS. Each milk sample is analyzed for low levels of radioiodine and other gamma emitting nuclides. Seven out of eight scheduled samples were obtained as the result of scheduling problems.

Table 13 Quarterly samples for radionuclides in milk

Linsey Dairy			Sunrise Dairy		
Date	I-131	K-40	Date	I-131	K-40
7/29/2008	<1	1408 ± 103	08/28/08	<1	1400 ± 122
12/2/2008	<1	1415 ± 107	11/28/2008	<1	1335 ± 116
3/10/2009	<1	1400 ± 122	02/26/09	<1	1341 ± 103
6/23/2009	<1	1265 ± 168	06/08/09	<1	1253 ± 118

Fish/Game Animals/Domestic Meat Samples

Fish samples were collected from the Coffey County Lake and below John Redmond Reservoir on the Neosho River. Sample portions from fish collected in the Coffey County Lake and below John Redmond Reservoir on the Neosho River were split with WCNOC. Fish collected at John Redmond Reservoir on the Neosho River are used for control samples. Eleven fish for a total of nine species were sampled.

Game animal sampling is usually limited to the collection of edible meat portions from road-killed deer. Sample portions of road-killed deer are usually collected as available by WCNOC and split with KDHE for laboratory analysis. One deer sample was obtained during SFY 2009.

A gamma isotopic analysis is done on all samples collected. Sample portions were edible. Tritium in tissue analysis (fat and water) is done on at least one species of fish from each location sampled. Results for October and November 2008 were rejected for being higher than lake water concentrations. Laboratory method was changed prior to May 2009 samples.

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Table 14 Annual samples for radionuclides in fish (pCi/kg, wet)

Location	Date	Description	³ H KDHE (WCNOC)
Q-1 (CCL)	10/17/2008	Smallmouth Buffalo	** (6215 ± 195)
		Wiper	** (6539 ± 221)
		White Bass	** (6937 ± 223)
Q-1 (CCL)	10/21/2008	Blue Catfish	** (5432 ± 195)
Q-1 (CCL)	10/29/2008	Walleye	** (4877 ± 194)
		White Crappie	** (3861 ± 167)
Q-1 (CCL)	5/29/2009	Smallmouth Buffalo	4090 ± 235 (6781 ± 222)
		Smallmouth Bass	4064 ± 225 (6852 ± 206)
		Largemouth Bass	6814 ± 296 (6681 ± 208)
		White Bass	5993 ± 272 (6820 ± 207)
		Bigmouth Buffalo	6115 ± 289 (7471 ± 230)
		Common Carp	5126 ± 291 (7319 ± 228)
		Flathead Catfish	4747 ± 243 (7367 ± 212)
N-1 (JRR) John Redmond Reservoir Below dam on Neosho River	11/14/2008	Common Carp	** (<142)
		Smallmouth Buffalo	** (<113)
		Channel Catfish	** (<114)
(Control)	5/28/2009	Common Carp	<1200(<124)
		Channel Catfish	<1200(<112)
		Smallmouth Buffalo	<1200(<115)

**Results rejected—tritium levels in fish were higher than lake water concentrations. KHEL method changed prior to May 2009 samples.

Table 15 Random samples for radionuclides in game

Sample Location	Date	Sample Type	K-40	Be-7
2.5 Mi. NNW of WCNOC	2/20/2009	Deer	2178 ± 303 (2970.0 ± 361.1)	<78 (Not Reported)

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Terrestrial Vegetation/Human Food Products

Terrestrial vegetation samples were taken at various locations around WCGS. This includes samples of crops grown throughout Coffey County, broadleaf vegetation taken from gardens near the WCGS boundary, and pasturage near WCGS. Samples collected on WCNOC property and samples of crops were split with WCNOC. Crops irrigated with water from the Neosho River were not available during SFY 2009, as the amount of rainfall received rendered irrigation unnecessary. A control sample was collected at Scott Valley Church approximately 6 miles from WCGS. Ten random samples were collected from locations around WCGS within the 50 mile zone.

A gamma isotopic analysis was done on each vegetation sample and edible portions of food products collected.

Table 16 Annual samples for radionuclides in terrestrial vegetation/human food products

Location	Sample type	Date	K-40 pCi/g KDHE(WCNOC)	Be-7 pCi/kg KDHE(WCNOC)
Scott Valley Church (Control)	Red Milo	9/24/2008	2537 ± 346	<360
Sector J, 8.9 mi. S of Wolf Creek (NR-D1)	Corn	10/13/2008	2317 ± 179 (2765.0 ± 187.2)	<360 (<53.2)
Sector K, 4.5 mi. SSW of Wolf Creek (NR-U1)	Corn	10/02/2008	2304 ± 196 (2710.2 ± 336.0)	<360 (<116.2)
Sharpe	Soybeans	10/28/2008	11082 ± 720	<360
Sector K, 4.5 mi. SSW of Wolf Creek (NR-U1)	Soybeans	10/27/2008	17252 ± 1677 (12605.0 ± 488.4)	<360 (<134.0)
EEA	Prairie Grass	5/26/2009	21317 ± 1686 (6429.0 ± 453.1)	<360 (466.8 ± 153.4)
MUDS	Pasturage	5/29/2009	16694 ± 1864 (5542.3 ± 470.7)	<360 (696.0 ± 178.6)

Table 17 Random samples for radionuclides in terrestrial vegetation/human food products

Location	Sample type	Date	K-40 pCi/g KDHE	Be-7 pCi/kg KDHE
Near Salava's Pond	Pasturage	6/9/2009	11538 ± 17665	<360
East of EEA	Wheat	7/10/2008	3443 ± 337	<360
20th Rd. and Reaper Rd.	Whole Corn	8/25/2008	3218 ± 279	<360
Near 16th Rd. and Reaper Rd.	Apples	8/26/2008	1801 ± 148	<360
Near 10th Rd. and Iris	Pears	9/3/2008	<152 ±	<360
Near Oxen Rd. and 9th Rd.	Red Milo	9/16/2008	1642 ± 160	<360
Near 9th Rd. and Shetland Rd.	Corn on Cob	9/16/2008	3493 ± 386	634 ± 87
19th Rd. Between Oxen and Planter	White Milo	9/24/2008	3278 ± 584	921 ± 584
12th and Native Rd.	Soybeans	10/8/2008	11337 ± 1061	814 ± 138
K-57 between Underwood and Verdure	Sunflower w/Seeds	10/28/2008	14634 ± 1020	<360
22nd Rd. between Underwood and Verdure	Soybeans	12/2/2008	9220 ± 606	<360

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Attachment 6: KDHE Radiochemistry Laboratory

Quality Assurance

The KDHE Radiation Laboratory has an established internal Quality Assurance program. Quality Control elements include routine calibrations and performance checks on counting equipment and participation in an environmental radioactivity laboratory intercomparison studies program. This program is currently accomplished with blind samples purchased from Environmental Resource Associates. Results for SFY 2009 are not available because of the retirement of the laboratory Senior Scientist in April, 2009.

Equipment

The following is a description of the equipment used by the KHEL Radiochemistry laboratory.

Multichannel gamma-spectrometer

Gamma radiation is measured spectra determined with a Canberra Genie-2000 Multichannel Analyzer

(MCA) system. Detectors available are three high purity germanium detectors (efficiencies – 20 % - 40%) and one germanium-lithium (GeLi) Detector (efficiency 20%).

Low background alpha/beta system

Low background alpha/beta gas-flow internal proportional counters – one Tennelec LB5100, one Oxford Series 5XLB, one Tennelec LB4000 multi-detector and one Canberra 2201.

Internal proportional counter (IPC)

Gross alpha and radium analyses are performed with windowless gas-flow internal proportional counters – four Protean MPC 2000 and two NMC PC5.

Liquid scintillation

Analysis for tritium in water is performed using a one Wallac 1409 and one PE Tri-Carb 3100 TR.

Miscellaneous equipment

The Radiochemistry Section has various devices used for special purposes. A Ludlum Model 2200 single channel analyzer is used with a radon flask scintillation counter for radon and radium analyses. Another Ludlum Model 2200 single channel analyzer is used with a halogen quenched GM pancake probe for routine monitoring of personnel and incoming samples.

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Table 18 Method Detection Limits

GeLi [HPGe] detection system ^a						
Environmental Sampling						
	Water and Milk	Filter	Wipe	Soil and Sediment	Biota	Vegetation and food products
Minimum sample size Minimum Counting Time Method Detection Limit	2000 m ³ 8 hr. pCi/l	1500 m ³ 3 hr. pCi/m ³	Total 3Hr. pCi/wipe	.45 kg 15 hr. pCi/kg-dry	0.3 kg 15 hr. pCi/kg-wet	1 kg 15 hr pCi/kg-dry
⁷ Be	64 [22]	0.03 [0.02]	****	346 [186]	231 [144]	35 [19]
⁴⁰ K	88 [39]	0.03 [0.02]	****	828 [654]	459 [262]	152 [72]
⁵¹ Cr	52 [32]	0.01 [0.009]	5 [3]	35 [22]	41 [32]	55 [46]
⁵⁴ Mn	4 [2]	0.004 [0.003]	1 [0.7]	44 [11]	30 [15]	72 [24]
⁵⁸ Co	4 [2]	0.008 [0.002]	2 [1]	45 [23]	37 [20]	92 [36]
⁵⁹ Fe	8 [3]	0.01 [0.01]	3 [2]	51 [16]	41 [15]	97 [52]
⁶⁰ Co	11 [7]	0.01 [0.0053]	2.5 [1.7]	56 [35]	43 [26]	79 [50]
⁶⁵ Zn	8 [4]	0.01 [0.007]	****	48 [30]	38 [22]	93 [63]
⁹⁵ Nb	7 [3]	0.009 [0.007]	2.5 [1.4]	68 [30]	44 [26]	9 [4]
⁹⁵ Zr	6 [3]	0.01 [0.002]	0.5 [0.3]	35 [27]	27 [19]	84 [54]
⁹⁹ Mo	5 [3]	0.002 [0.0014]	1 [0.6]	73 [43]	33 [21]	****
¹⁰³ Ru	10 [7]	0.004 [0.003]	****	29 [20]	29 [21]	69 [47]
¹⁰⁶ Ru	55 [43]	0.07 [0.05]	1.5 [1]	269 [192]	43 [29]	96 [65]
^{110m} Ag	4 [3]	0.006 [0.0002]	****	47 [33]	47 [34]	86 [55]
¹²⁵ Sb	35 [12]	0.02 [0.01]	****	97 [44]	96 [51]	15 [6]
¹³¹ I	5 [3] (1) ^b	0.00027 [0.00027] ^c	1.5 [1]	33 [20]	37 [23]	45 [13]
¹³⁴ Cs	5 [3]	0.007 [0.004]	1.4 [1]	44 [29]	37 [24]	57 [39]
¹³⁷ Cs	7 [4]	0.006 [0.004]	1 [0.3]	49 [29]	32 [21]	80 [56]
¹⁴⁰ Ba	10 [6]	0.004 [0.003]	****	26 [17]	24 [15]	60 [39]
¹⁴⁰ La	9 [5]	0.01 [0.02]	****	28 [9]	34 [21]	13 [6]
¹⁴¹ Ce	8 [3]	0.002 [0.001]	****	46 [23]	22 [13]	6 [3]
¹⁴⁴ Ce	35 [14]	0.013 [0.0096]	****	216 [103]	110 [70]	28 [14]
²²⁶ Ra	116 [69]	0.05 [0.03]	****	828 [654]	323 [195]	90 [51]
²²⁸ Ac	30 [18] 15 h	0.0127 [0.0099]	****	68 [33]	146 [87]	27 [12]
²²⁸ Th	387 [142]	0.09 [0.06]	****	859 [317]	944 [356]	454 [167]
²³⁴ Th	618 [87] 15 h	0.159 [0.0423]	****	1009 [378]	1300 [556]	570 [94]
²³⁵ U	****	****	45 [30] 15 h	****	****	****
²³⁹ Np	41 [33]	0.01 [0.009]	5 [3]	64 [44]	40 [30]	97 [71]

^a GeLi = Germanium lithium; HPGe = High purity germanium.

^b Two methods of analysis are done: **1)** 8 hour direct gamma isotopic analysis of a 2000 m³ milk or water sample that has a method detection limit (MDL) of 3 pCi/R, and **2)** 3 hour gamma isotopic analysis of ion exchange resin after a 1500 m³ milk sample is filtered through an ion exchange column that has an MDL of 1 pCi/R.

^c The MDL for ¹³¹I when analyzing a charcoal cartridge is 0.03 [0.02] pCi/m³ based upon a 250 m³ sample volume. If the sample volume is increased to 1500 m³, the MDL is 0.002 [0.001] pCi/m³.

Method detection limits of present analytical methods for selected radionuclides monitored by the KHEL Radiochemistry Laboratory. These limits are intended as guides to order of magnitude sensitivities and are calculated with a 95% level of confidence (activity will be detected 95% of the time if it is present).

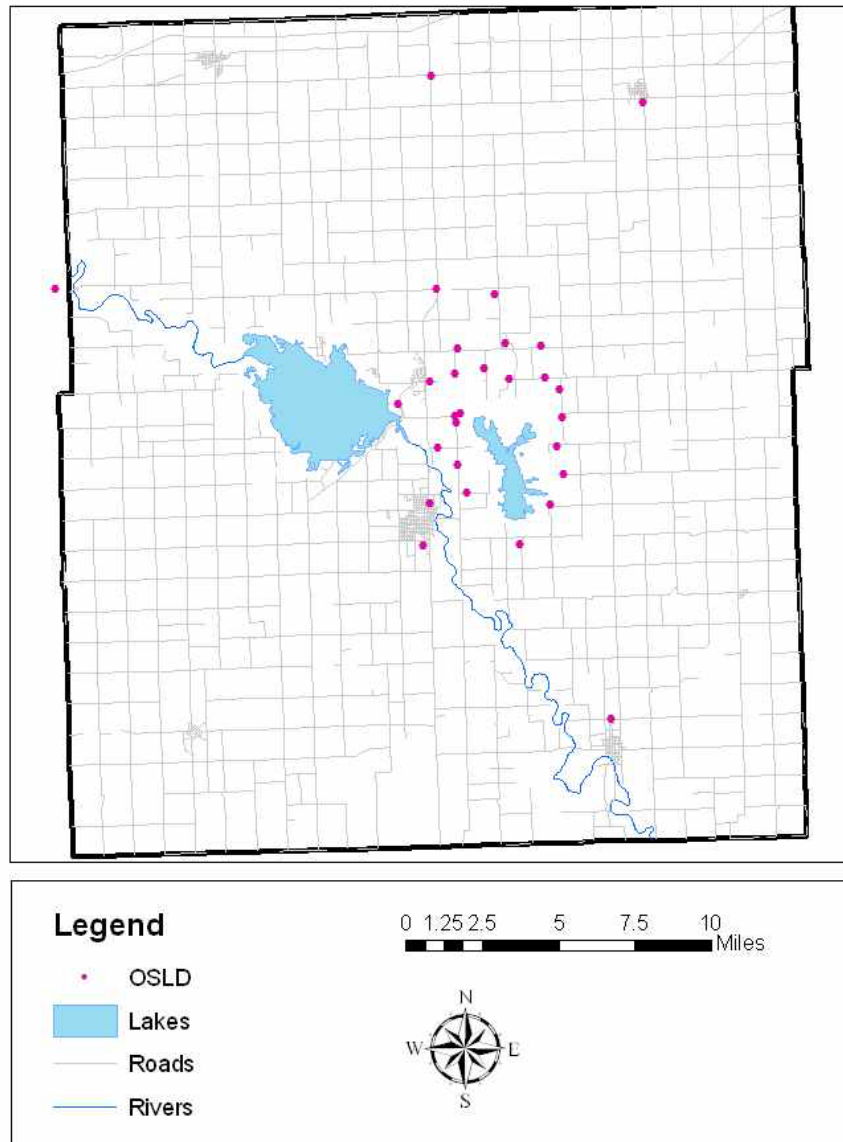
Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Low Background Alpha and Beta Counting System					
	Water	Milk	Wipe	Soil and Sediment	Vegetation and Food products
Minimum Sample Size	1000 ml	1000 ml	Total	0.01kg	0.1 kg
Minimum Counting Time	200 min.	200 min.	200 min.	200 min.	200 min.
Method Detection Limit	pCi/L	pCi/L	pCi/wipe	pCi/kg-dry	pCi/kg-dry
⁸⁹ Sr	1	2	3	200	500
⁹⁰ Sr	1	2	4	200	500
¹³¹ I	1	****	****	****	****
²²⁸ Ra	1.2	****	0.3	60	****
Gross Beta					
	Water		Filter		Wipe
Minimum Sample Size	200 ml		250m ³		Total
Minimum Counting Time	200 min.		100 min.		100 min.
Method Detection Limit	4 pCi/l		0.004 pCi/m ³		2pCi/Wipe
Gross Alpha					
	Water		Filter		Soil and Sediment
Minimum Sample Size	200 ml		250 m ³		0.001 kg
Minimum Counting Time	200 min.		100 min.		100 min.
Method Detection Limit	1 pCi/l		0.0006 pCi/m		160 pCi/kg-dry
Random Scintillation Counting System					
²²⁶ Ra (radium) in water					
Minimum Sample Size	1000 ml				
Minimum Counting Time	200 min.				
Method Detection Limit	0.04 pCi/l				
Liquid Scintillation Counting System					
	Tritium (³ H)		²²² Rn (Radon)		
	In water	In Tissue	In Water		
Minimum Sample Size	10 ml	3 g	10 ml		
Minimum Counting Time	100 min.	120 min.	60 min.		
Method Detection Limit	350 pCi/l	1200 pCi/kg-wet	25 pCi/l		

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

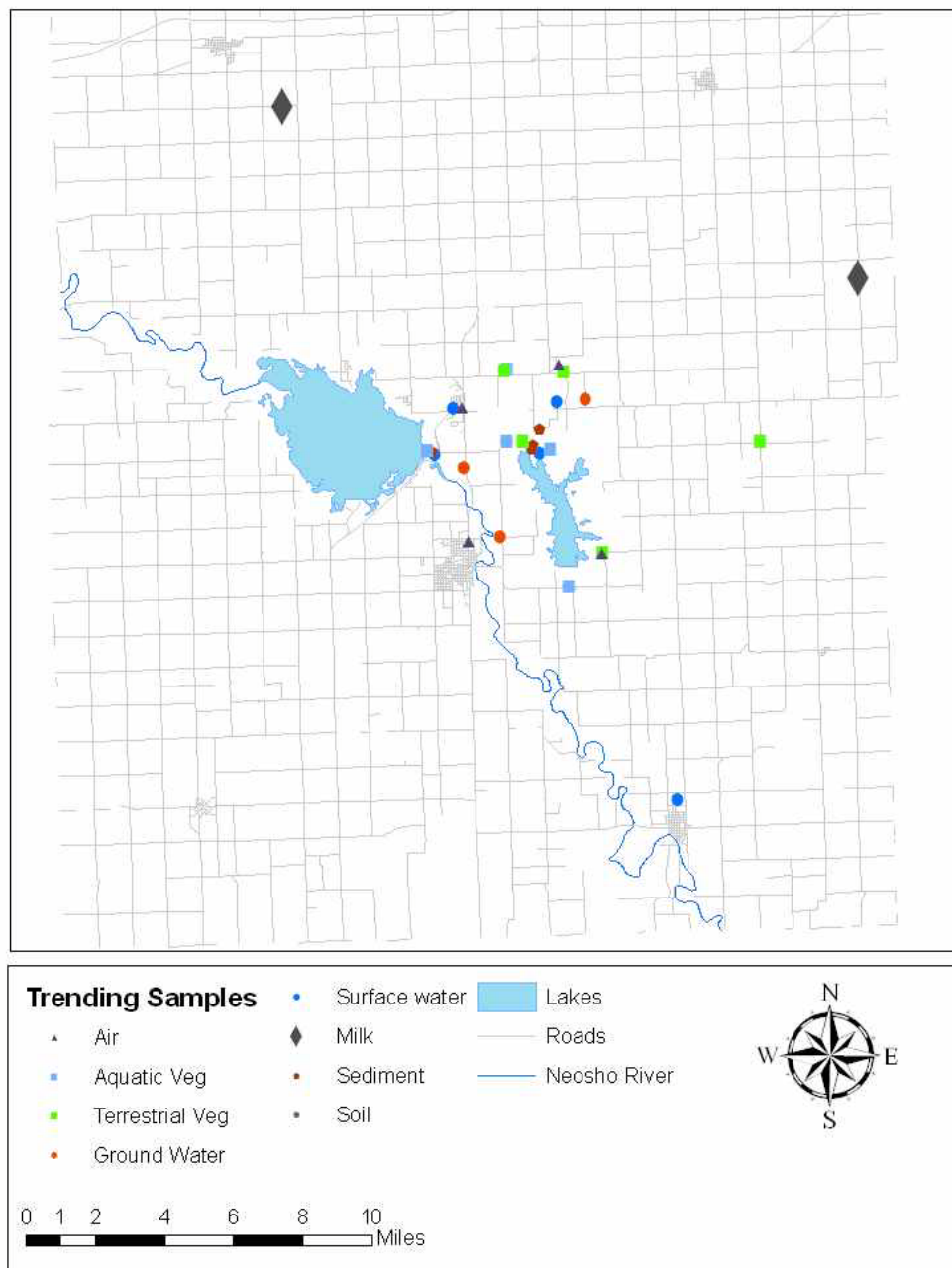
Attachment 7: Maps

Map 1 OSLD Locations



Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Map 2 Routine Sample Locations



Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
State Fiscal Year 2009

Map 3 Random Sample Locations

